Technology Corner

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Optimization of Left Lane Traffic Signals

INTRODUCTION & SCOPE

Traffic signals are installed to provide safe and efficient movement of vehicles through intersections. However; when it comes to "Permitted" and "Protected" left-turn phasing, safety and capacity issues often create problems for traffic engineers. By definition "Protected" left-turn phasing describes left-turn movements which can only be made on a green arrow with opposing flow stopped, while "Permitted" left-turns are executed through gaps in the opposing traffic. A combination of "Permitted" and "Protected"(P/P) phasing is often used on a single approach. Under this (P/P) situation, the "Protected" phase is activated by the presence of a vehicle in the left-turn lane.

Naturally, as opposing traffic and left-turn volumes increase the traffic flows are reduced and left-turning vehicles are increasingly delayed. When these conditions, along with decreased safety (safety is the primary concern in determining this decision in Utah) are incurred a decision needs to be made whether to install "Protected" or P/P phasing. The "Protected" or P/P phasing can satisfy the left-turning demand, but may delay overall intersection movement. Research was conducted by the University of Utah under the direction of Peter T. Martin, Ph.D. to develop general guidelines on how to select the appropriate type of left-turn phasing. The research was addressed in three-phases:

Phase I - Assess the delay due to "Permitted," "Protected" and P/P left-turn phasing under various opposing flow and left-turn traffic conditions and road geometry.

Phase II - Identify where queue detectors should be placed in order to activate "Protected" left phasing for P/P left-turn phasing. By assessing left-turn and overall intersection vehicle delays for different opposing flow conditions along with left-turn queue lengths an optimal queue length was determined. This optimal location will vary based on opposing flow and left-turn queued vehicles.

Phase III - Develop guidelines to help in determining the need for separate left-turn phasing regimes based on conflicting traffic volumes.

While left-turn accidents and the left-turn impacts on signal coordination are not addressed by this study, it does address: the type of left-turn phasing which is most efficient under a given flow condition; when queue length should be detected; and the general guidelines addressing future decisions on implementing left-turn phasing.

UDOT Research Division, Box 148410., SLC, UT 84114-8410 Phone: 801) 965-4196
Fax (801) 965-4796

CONCLUSIONS & RECOMMENDATIONS

Results from this study equates the performance of left turn phasing in order to provide quantifiable benefits of one phasing over another. "Permitted," "protected" and P/P phasing were analyzed for a range of left-turn volumes and opposing through traffic in order to develop relational curves. The measure of left-turn and overall intersection delay was used to compare the different phasing performances. Specific consideration is given to determining the optimal location of the queue detector for P/P phasing. From the analysis, guidelines were developed for determining the type of left-turn phasing based on left-turn volume, opposing through volume and lane geometry.

The analysis indicates that P/P phasing provides the best method of left-turn phasing signal control. This type of phasing allows for a wide range of control and is better able to accommodate the changing volumes throughout the day. The optimal queue detector location of P/P varies based on opposing volume and geometry. UDOT has typically placed the queue *detector location at the third vehicle. This is based on "Permitted" phasing to accommodate two sneakers per cycle. Therefore, the third vehicle location triggers the "Protected" phasing so that all left turning vehicles can be accommodated. However, this assumes that no gaps exist in the oncoming traffic to provide capacity for left-turns and that the opposing traffic is operating near capacity. Based on this same assumption, delay comparisons indicate that geometry and queue location are related. For a single lane geometry, the third vehicle location is appropriate. However, as the geometry is increased to two or three lanes, the opposing through volume increases and the overall intersection delay is reduced when the detector location is moved to the forth vehicle location.

Other recommendations of the study support:

l-P/P phasing be installed at all intersections unless:

- -Left-turn demand averages 2 or less vehicles per cycle.
- Safety requirements warrant a "Protected" phase. These include...
  - . ..geometric site distance restrictions of less than 250 feet for speeds up to 35 mph and less than 400 feet for speeds of 40 mph and greater.
  - . ..opposing speed greater than 45 mph.
  - . ..opposing number of lanes greater than 3
  - . . ..historical accidents of 5 per year or 8 in 2 years, which could have been prevented by a protected left turn phase.

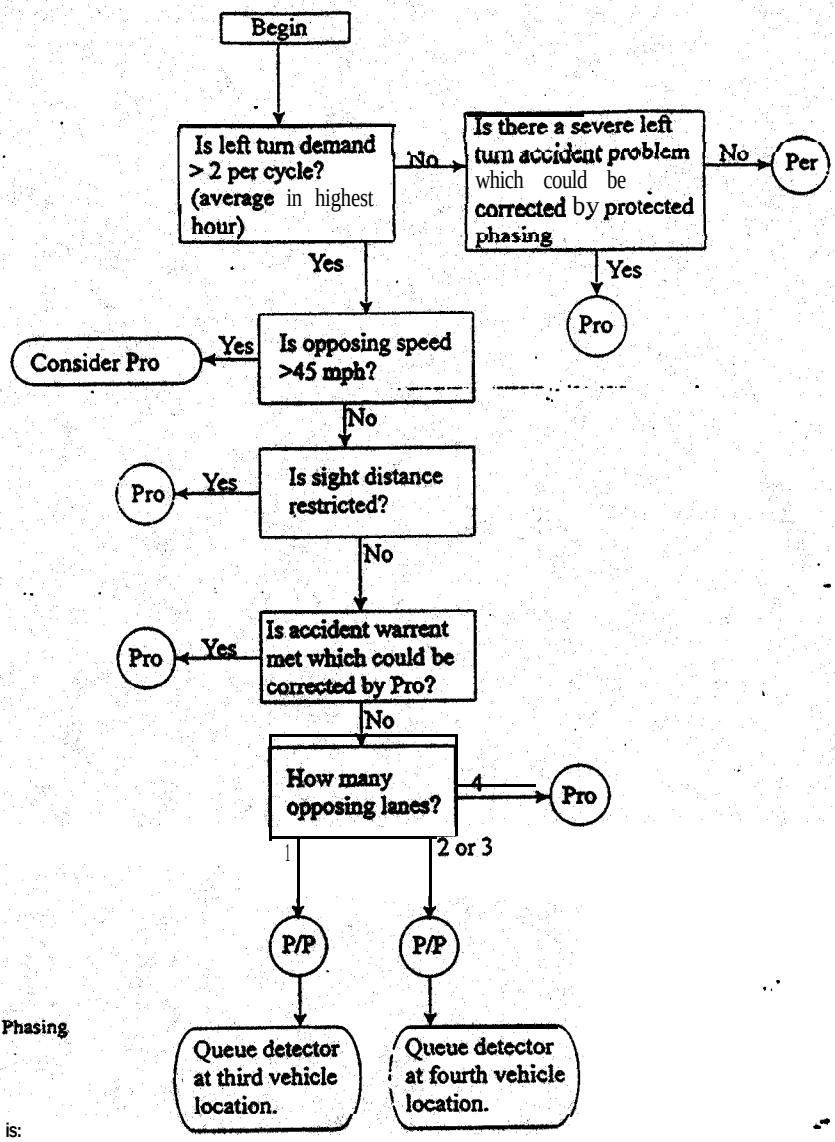
2-Once P/P phasing is implemented, the optimal queue location will vary based on the opposing through volume demand and number of lanes.

3-With 1 opposing lane, the third vehicle is the queue detector location.

4-With 2 opposing lanes, the fourth vehicle is the queue detector location.

5-With 3 opposing lanes, the fifth vehicle is the optimal queue detector, however engineering judgement may justify using the forth vehicle.

6-The following flowchart of left turn phasing is based on accident, lane geometry, sight distance and demand and can be used to guide traffic engineers in the decision process.....



Pro = Protected Phasing
Per = Permitted Phasing
P/P = Permitted/Protected Phasing

Restrictive Sight Distance is:

<250 feet when speeds are 35 mph or less
<400 feet when speeds are 40 mph or more

NOTE: Comprehensive results can be obtained by contacting the UDOT Research Division @ (801)965-4196: Refer to Report # UT-96.08, Titled: Optimization of Left Lane Traffic Signals

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